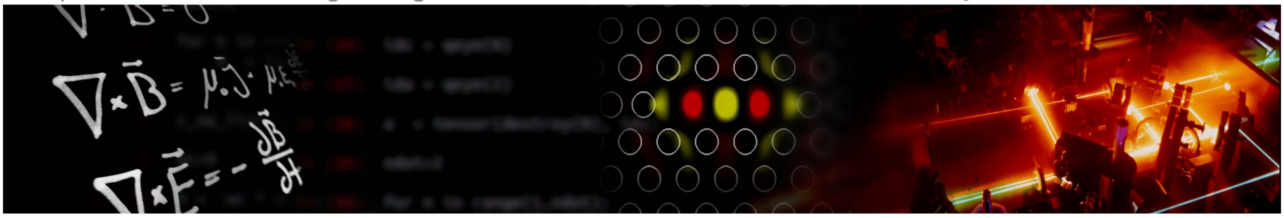

M.Sc. project

Acoustic grating reflector: analogy between acoustic and photonic wave equations

The aim of this theoretical project is to investigate the reflection properties of the acoustic sub-wavelength grating by using analogy between photonic and acoustic wave equations.

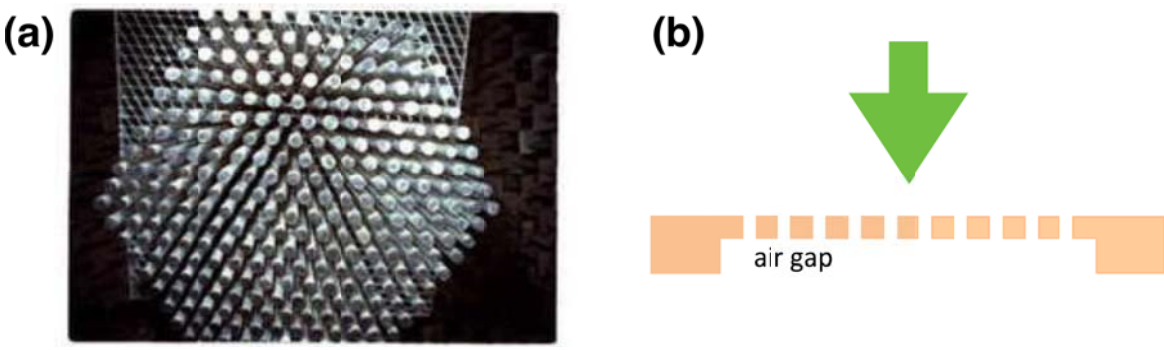

Figure 1. (a) An example of acoustic bandgap material. (b) Schematic of the high contrast grating.

It is well known that the similarity between the Schrodinger equation for electrons and the wave equation for photons leads to lots of analogy between solid-state materials and photonic crystals. Interestingly, such a similarity is found also between the acoustic and the photonic wave equations. For example, as shown in Fig. 1(a), a periodic array of materials called acoustic bandgap material may have a specific frequency range at which acoustic waves cannot propagate. This frequency range is called acoustic bandgap. To have a high reflection for incident acoustic waves, several periods of materials are required.

In the photonic counter part, it has been recently reported that a thin single grating layer called high-index-contrast grating (HCG) as shown in Fig. 1(b), can exhibit very high reflectivity over an even broader frequency range than the photonic bandgap material. The reflection mechanism of the HCG is quite different from that of the photonic bandgap material. DTU has been among pioneers for research on the HCG, e.g. [1-3]. Referring again to the analogy between the acoustic and the photonic wave equations, we expect that an acoustic version of the HCG is likely to exist. If it exists, it can potentially innovate lots of acoustic wave related designs. Possible applications include compact earthquake wave reflector, compact sound waveguide, compact sound lens, and compact sound resonator. DTU Fotonik has extensive theoretical experiences on conventional acoustic bandgap materials, e.g. [4, 5].

In this project, we aim at goals as follows (which can be modified according to the student's interest):

- Find and understand the Eigen modes in sub-wavelength acoustic grating.
- Apply analogy with the HCG to identify whether similar functionalities exist.
- Propose an optimized reflector design.

For these goals, you will do numerical simulations and theoretical analysis of them. This requires solid understanding on electromagnetism. A basic understanding on programming is a plus. If successful, the outcome of this project could be developed as a Ph.D. project that may include the experimental activity. Thus, this project is open not only for a student interest in theory, but also for one in experiment.

If you want to hear more about the project, you are encouraged to come by our offices or send us an email.

Supervisors:
Il-Sug Chung (ilch@fotonik.dtu.dk, Office 345v/170)
Morten Willatzen (morwi@fotonik.dtu.dk, Office 345v/171)

References:
[1] I.-S. Chung et al., IEEE Photonics Technology Letters **20**, 105 (2008).
[2] I.-S. Chung et al., Applied Physics Letters **97**, 151113 (2010).
[3] A. Taghizadeh et al., Optics Express **22**, 21175 (2014).
[4] J. Christensen et al, Physical Review B **85**, 094304 (2012).
[5] J. Christensen et al., Scientific Report **4**, (2014).